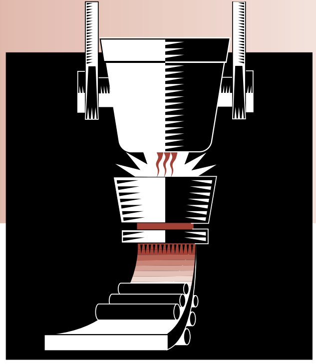
STEEL

Project Fact Sheet



In-Situ, Real-Time Measurement of Melt Constituents

Benefits

- A cumulative reduction of 55 to 83 trillion British thermal units (Btu) per year, including a 12 trillion Btu reduction for the aluminum industry, 17 to 45 trillion Btu for the glass industry, and 26 trillion Btu for the steel industry
- In-situ, real-time, simultaneous determination of melt constituents and temperature with a system costing less than $100,000
- Data for use in a feedback control loop to control the furnace operation in real time
- Minimization of glass product rejections resulting from variations in glass melt composition and non-repeatability in the mechanics of forming
- Elimination of the aluminum and steel furnace idle time now required for off-line measurement of melt constituents

Applications

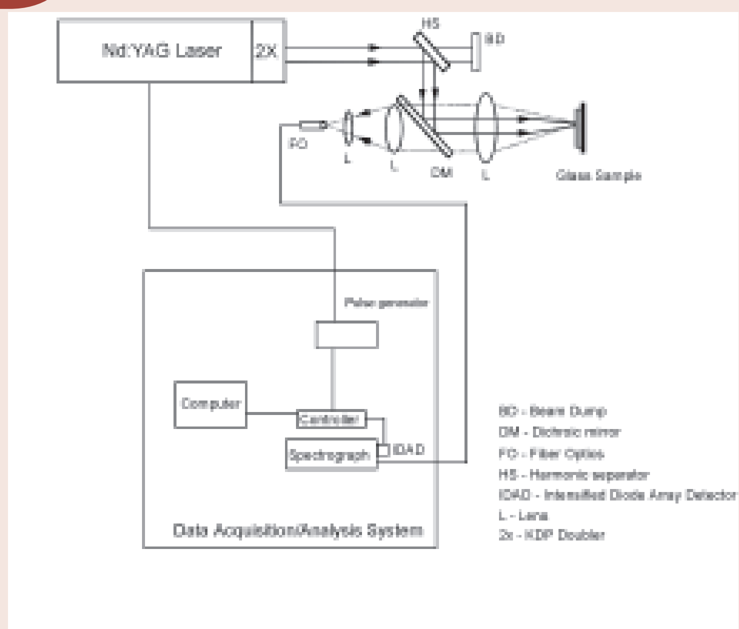
The primary target applications are in the aluminum, glass, and steel industries. In the glass industry, application is especially suited for monitoring of trace alkali metal content in electronic glasses, compositions to meet the defined specifications for waste-vitrified glasses and sealing glasses, and the concentration of refractory dissolved in the glass to diagnose the state of the furnace. Applications in the aluminum and steel industries relate to: in-line alloying by measuring during a pour; continuous and semi-continuous furnace operations by minimizing the current practice of off-line sampling and measurement; in-line monitoring of removal of impurities from the melt such as the removal of magnesium from molten aluminum; and validation of computer simulation and modeling of furnaces with real-time data.

Laser-induced breakdown spectroscopy will provide real-time elemental constituents for product quality control

This technology employs a laser-induced breakdown spectroscopic (LIBS) technique to measure, in-situ and in real-time, the constituents of the melt in a process furnace. Currently, elemental analysis is conducted by periodically grabbing a molten sample and taking it to a lab for analysis. This is expensive and time consuming, and it does not allow real-time control. By allowing in-situ, real-time measurement of melt constituents, this technology will improve product quality by reducing defects, increase furnace cycle times leading to continuous and semi-continuous operations, increase furnace life by diagnosing the state of the furnace, and provide necessary data to develop and validate computer modeling and simulation leading to increased automation of furnace operations.

The commercial LIBS technique for in-situ analysis of molten steel is too costly, ranging from $750,000 to $2 million. This project aims at producing a system for less than $100,000, which industry representatives predict will overcome the cost barrier for technology acceptance.

LIBS Probe



The LIBS probe being developed will improve product quality, increase furnace production, reduce energy use, allow continuous furnace operation, and validate computer models.

Project Description

Goals: Develop and test a LIBS-based probe in a laboratory crucible furnace to demonstrate in-situ, real-time measurement of melt constituents with an accuracy and minimum detection limit of 5 percent and 0.01 percent, respectively.

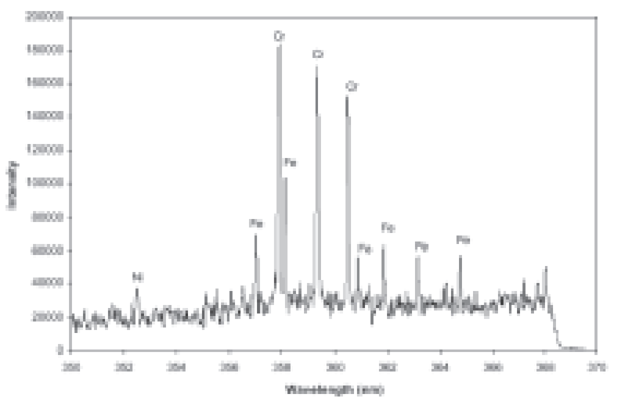
The LIBS technology employs a laser and a spectrometer to measure, in situ and in real time, the constituents of the melt in a process furnace. A pulsed (5-10 ns duration) Nd:YAG laser at 532 nm is focused, through a fiber-optic cable, into a molten aluminum sample, generating high-temperature plasma consisting of excited neutral atoms, ions, and electrons. Any chemical compounds that are present in the sample are rapidly dissociated into their constituent elements. The laser-generated plasma is allowed to equilibrate several microseconds after the laser pulse, and optical emission from neutral and ionized atoms is collected and then dispersed by a spectrograph fitted with an intensified charge-coupled array detector. The line radiation signal amplitude can be calibrated quantitatively, thus providing the concentration of each element present.

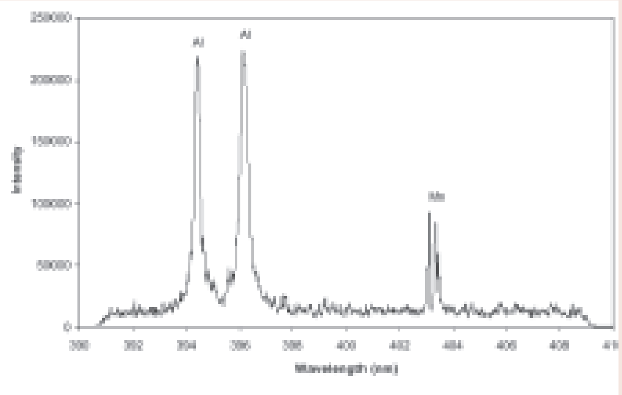
Progress and Milestones

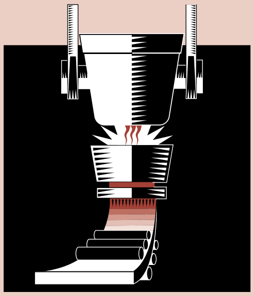
This project was selected through the Sensors and Controls Program fiscal year (FY) 1999 solicitation and was awarded in January 1999. All tasks are scheduled for completion in 36 months. Key project tasks that have been performed or are planned are:

- Laboratory development work has been completed.
- Conduct pilot-scale testing.
- Conduct testing at a commercially operating metals industry furnace.

In these two sample LIBS spectra, taken from within a molten aluminum bath, the melt constituents are clearly visible. Using a solid aluminum plate for a calibration source, the melt constituent concentrations were determined. The resulting concentrations and accuracies exceeded the original project goals.







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February 2001